MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

EMG4096 – RADAR SYSTEMS DESIGN AND ANALYSIS

(TE)

20 OCTOBER 2016
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only .
2. The student is required to answer all questions in the this question paper. Each question carry a particular marks and the distribution of the marks is given .
3. Please print all your answers in the Answer Booklet provided .

Question 1

(a) With aid of a radar block diagram, describe the basic radar operation.

[9 marks]

(b) An L-band radar system is designed to determine the range of the moving vehicle. In this system, the operating frequency is 5.3 GHz. The radar cross section is 10 m^2 with maximum range of detection of 250 meters. The antenna gain is 20 dBi with a pulse width of 10 ns. The minimum detectable signal is to be 15×10^{-13} W. Find the following:

(i) Pulse repetition frequency (PRF) if range measurement must be unambiguous.

[2 marks]

(ii) Resolution in range.

[2 marks]

(iii) Duty cycle.

[3 marks]

(iv) Average power required to detect a radar cross section vehicle at a maximum range.

[3 marks]

(c) List down two major categories of clutter. Provide examples (2 for each category) for each of the category of the clutter.

[6 marks]

Continued .....

Question 2

(a) A Frequency Modulation Continuous Wave (FMCW) radar operates at 6 GHz. The frequency increases at a rate of 2 GHz/s for 1000 μs and then returns to its original value in another 1000 μs.

(i) Sketch the FMCW waveform with frequency versus time.

[5 marks]

(ii) What is the beat frequency of the echo from a fixed target at a range of 3000 m?

[3 marks]

(iii) What is the beat frequency components ($f_{IF,up}$ and $f_{IF,down}$) if the target is located at 3000 m and closing at a rate of 50 m/s?

[6 marks]

(iv) Sketch the return signal for Q2 (a) (iii).

[5 marks]

(b) Explain what is meant by Radar Cross Section (RCS). State the theoretical definition of the RCS.

[6 marks]

Continued .....

Question 3

(a) Differentiate among low, medium and high pulse repetition frequency (PRF) requirement of a radar system in term of power, range and Doppler. The answer should be presented with the format of the table as shown below.

[6 marks]

	Power	**Range**	**Doppler**
Low PRF			
Medium PRF			
High PRF			

(b) In a coast monitoring radar system, an L-band utilizes a staggered waveform and frequency of 1.25 GHz is used. There are four different pulse repetition frequencies (PRFs), which are 500 Hz, A, B and 1000 Hz. The values for the integer, ni for these four frequencies are 40, 32, 25 and C respectively. Note that the constant pulse repetition frequency is used which has a pulse repetition period equal to the average of the four periods of the staggered waveform. Determine the following;

(i) Value of A, B and C.

[3 marks]

(ii) Blind speed for each of the individual PRF.

[4 marks]

(iii) First blind speed of the staggered pulse repetition waveform.

[4 marks]

(c) Distinguish between angle tracking and range tracking. Draw a related diagram to support your answer.

[8 marks]

Continued .....

Question 4

(a) An X-band pulse radar has the following specifications:

probability of detection $P_d = 0.90$
time of false alarm $T_{fa} = 6$ minute 40 second
operating bandwidth $B = 2.5$ MHz

The probability of detection versus single pulse Signal-to-Noise-Ratio (SNR) for several values of P_{fa} is shown in Fig. Q4 (a). Assume single pulse processing.

(i) Compute the probability of false alarm P_{fa}.

[3 marks]

(ii) Determine the signal to noise ratio (SNR) at the detector's input.

[3 marks]

(iii) At what SNR would the probability of detection drop to 0.75 (with P_{fa} not changed)? Comment the finding.

[4 marks]

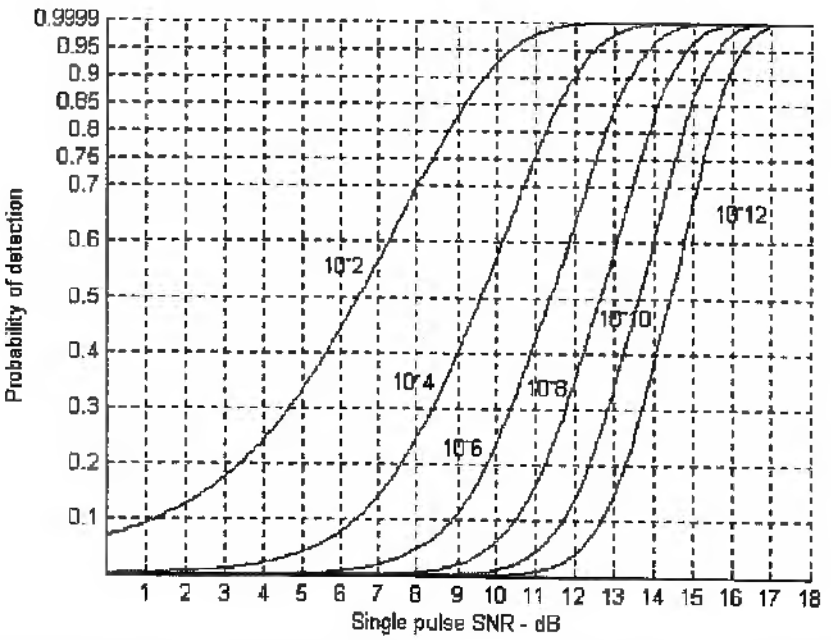

Fig. Q4 (a) Probability of detection versus single pulse SNR for several values of P_{fa}

Continued .....

(b) Fig. Q4(b) shows the block diagram of airborne synthetic aperture radar (SAR) system.

(i) What is the main purpose of using dual antenna system in this design?

[3 marks]

(ii) What is the main disadvantage of the circulator if we replace the dual antenna system in the figure to single antenna with circulator?

[3 marks]

(iii) What is the main objective of Low Noise Amplifier (LNA) in the receiver?

[2 marks]

(iv) What is the main function of the 100 MHz oscillator in this design?

[2 marks]

(v) A 500 MHz A/D is used to sample the return echo. What is the maximum allowable bandwidth for the based-band/Intermediate Frequency (IF) signal in this design?

[3 marks]

(vi) Calculate the range resolution of SAR system in Fig. Q4 (b)

[2 marks]

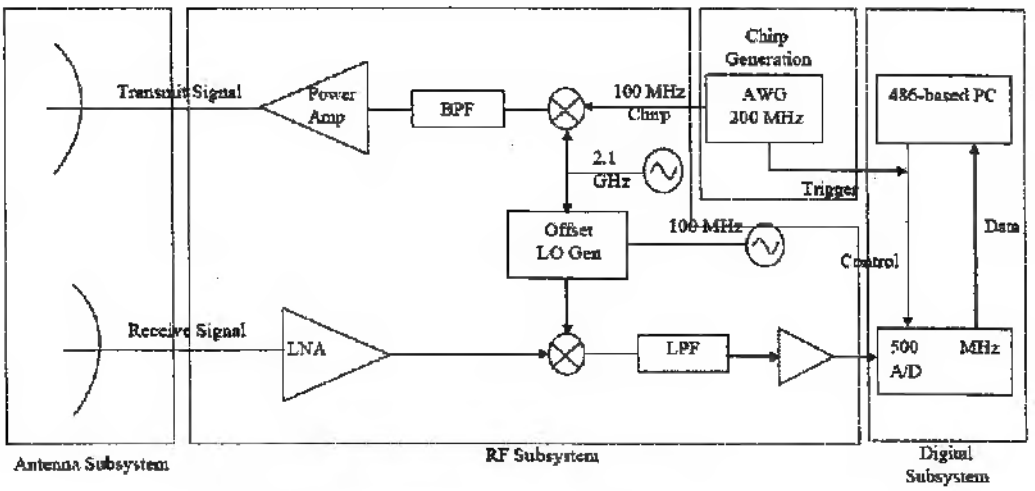

Fig. Q4 (b) Block Diagram of Airborne SAR System

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